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UM ESTUDO SOBRE OS DESAFIOS E PECULIARIDADES DE MONTAGENS E INSTALAÇÕES DE REDES DE DADOS TEMPORÁRIAS

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Um estudo sobre os desafios e peculiaridades de montagens e instalações de redes de dados temporárias.

Trabalho de conclusão de curso de graduação apresentado ao Departamento de Ciência da Computação da Universidade Federal do Rio de Janeiro como parte dos requisitos para obtenção do grau de Bacharel em Ciência da Computação.

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RESUMO

O autor desde documento trabalhou pelos últimos 3 anos como arquiteto de redes (e em alguns casos como gerente de projetos) na indústria de eventos, em diversas montagens distintas. O principal objetivo do documento é trazer um a visão geral sobre as peculiaridades e desafios que um projetista de redes deverá considerar ao projetar uma rede de dados temporária. Diversas características de redes temporárias são abordadas, incluindo exemplos práticos e soluções adotadas em redes cabeadas e sem fio. Aspectos nos quais as redes temporárias são mais simples do que redes permanentes também são abordados. A dissertação inclui 2 estudos de caso no seu último capítulo, com o objetivo de exemplificar na prática os aspectos abordados nos capítulos anteriores.

Palavras-chave: Redes temporárias. Eventos. Internet. Instalações temporárias. Wifi.

ABSTRACT

The author has been working for the past 3 years as a network engineer (and in some cases as a project manager) in the event industry, in several different setups. The main objective of this work is to provide a clear overview of the peculiarities that a network engineer must consider when projecting a network that will function for a determined amount of time. Several characteristics of temporary installations are mentioned, including practical examples of solutions for challenges imposed by cabled and wireless networking solutions. Aspects in which temporary networks are easier to implement than permanent networks are also addressed. The dissertation includes two case studies in its last chapters, with the objective of showing practical examples of facts mentioned in previous chapters.

Keywords: Temporary networks. Events. Internet. Temporary Installation. WiFi.

LIST OF FIGURES

LIST OF ABBREVIATIONS

AP	-	Access Point
APAC	-	Group formed by Asian and Pacific Countries
AV	-	Audio/Video
CAGR	-	Compound Annual Growth Rate
CDP	-	Cisco Discovery Protocol
CEIR	-	Center for Exhibition Industry Research
GUI	-	Graphical User Interface
IEEE	-	Institute of Electrical and Electronics Engineers
ISP	-	Internet Service Provider
LAN	-	Local Area Network
NAG	-	Network Allocation Grid
NOC	-	Network Operation Center
OSI	-	Open Systems Interconnection
SNMP	-	Simple Network management Protocol
UFI	-	Union des Foires Internationales or Union of International Fairs
UTP	-	Unshielded twisted pair
VLAN	-	Virtual Local Area Network
WLAN	-	Wireless Local Area Network
WLC	-	Wireless LAN Controller

SUMMARY

1 INTRODUCTION

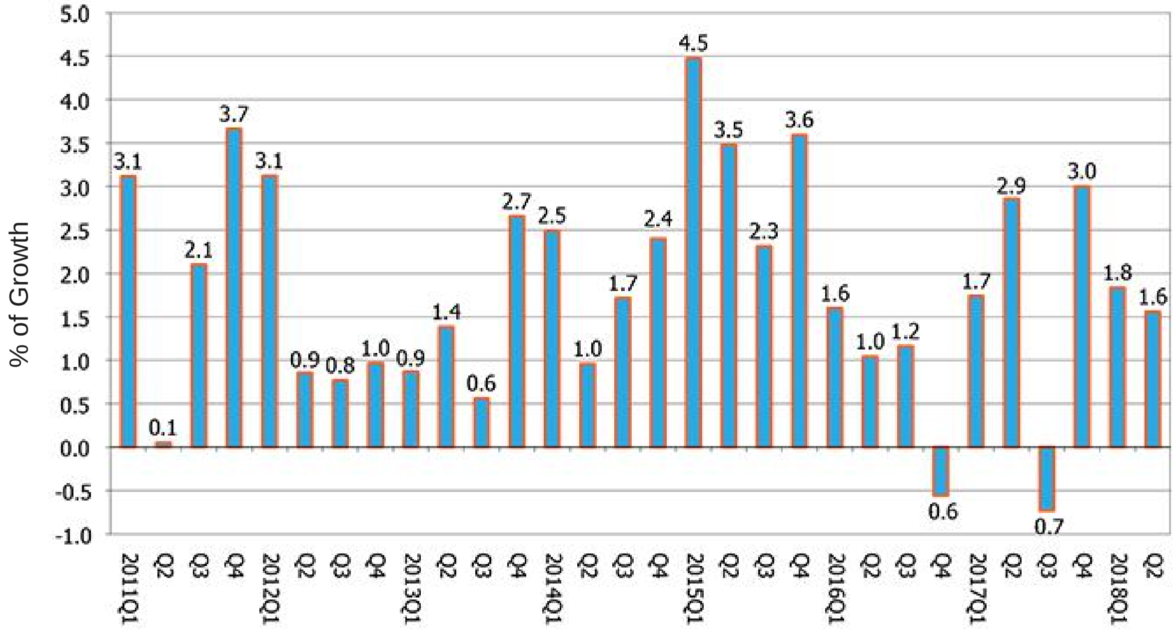
Having worked on the event and exhibition industry for the past 3 years, the author of this work has faced several different challenges in the setup of computer network connectivity in events. These setups are usually very different from traditional networks, and therefore, require a different approach in planning, preparing, deploying, monitoring and disassembling. In order to identify these differences, and approach the problem in an efficient way, one first needs to understand the nature of events and the exhibition industry.

1.1 The Event and Exhibition Industry, And Its Recent Growth.

The Sustainable Events Alliance defines an event as “any public gathering of people for a purpose” (SUSTAINABLE EVENT ALLIANCE, 2018). By definition, events are diverse. An event can be a conference, a summit, a meeting, a festival, an exhibition, a product launch, a sport spectacle, a cultural spectacle or corporate hospitality. Events contribute to several areas of the economy - such as tourism, development of exports, information exchanges, product marketing and corporate networking.

Over the past decade, the events and exhibition industry has experienced a substantial growth, in every one of its aspects. According to the Center for Exhibition Research (2015), the exhibition industry has been growing an average of 3.1 percent year-over-year. This accounted for 21 consecutive quarters of year-over-year increases, and in that same year, the industry has outperformed the macroeconomy numbers. In 2017, despite the slowdown in global economic growth, the exhibition industry has still grown, according to the recent 18th UFI Global Barometer survey (UFI GLOBAL EXHIBITION BAROMETER, UFI, 2017). As seen in Figure 1, the Center for Exhibition Industry Research has recorded continuous growth rates in the past quarters.

Figure 1: Quarterly CEIR Total Index for the Overall Global Exhibition Industry, 2011Q1-2018Q2



Source: Azorth Analytics (2018)

1.1.1 Possible Reasons for this substantial growth

Most of this growth can be explained by the way enterprises are seeing the need of a closer relationship with their target public. Former President of the UK International Special Events Society (ISES) (FOULKES, 2012) stated:

> "Businesses recognize a need for deeper engagement with customers and staff so they're investing more in events. Other forms of marketing provide broad brushstrokes, whereas events target specific groups and enable focused customer conversion. Face-to-face conversion has a far greater success rate on future sales. It creates word-of-mouth advocacy, which has a very powerful reach in a digital age. The Olympics and, in particular, the Paralympic Games has shown us that by creating an emotional connection through an event, it lifts morale, gets people talking, and engages them with specific brand messaging and values."

According to the recently published Azoth Analytics report (Global Exhibition Industry: Trends, Opportunities and Forecasts (2016-2021) - 2018), Global Exhibition industry market grew at a CAGR of approximately 3.55% during the 2011-2015 period. The report forecasts that the exhibition industry will grow at a CAGR of 5.07% during the period 2016-2021, especially due to the rising number of exhibitions in the emerging economies of the world. Therefore, the emerging markets' continuous growth should be the biggest players in this scenario.

The report also states that "although USA has the moderate growth rate, it holds the maximum market share, while APAC region has a huge growth opportunity accompanied with immense growth potential in Hong Kong, China and India."

The growth of the event industry is not only seen in the USA, it is a global phenomenon. In 2017, (LIVECOM ALLIANCE, 2017) the LiveCom Alliance European Industry Survey revealed that in Europe "countries are showing substantial growth expectations for events; average (43%). Event marketing budgets are rising by between 4.2% and 13.7%."

Many aspects have contributed to the growth of the event industry in the past decades, but according to (ASSAF, 2018) a student from Temple University in Philadelphia, while writing for the Socialtables blog, globalization is the main reason for the rapid takeoff of the industry. She states:

> "As business becomes increasingly globalized, event attendees are coming from a multitude of different countries. In this field that has us constantly interacting and communicating with other people, these trends are important to realize and understand in order to plan successful events."

1.2 The Ever-growing Need for Connectivity in Events.

> "The Internet has turned our existence upside down. It has revolutionized communications, to the extent that it is now our preferred medium of everyday communication. In almost everything we do, we use the Internet."
>
> (DENTZEL, 2013)

As stated in the citation above, the internet has changed the world, and by no means it is any different in the event industry. According to (GRATE, 2017a) while writing for the Eventbrite, "affordable, reliable connectivity is a must for today's events, but many venues do not provide adequate [...] Wi-Fi capabilities and charges." With the power of one click, a local event can be world-wide in a matter of seconds. With a single *tweet* an attendee publishes his experience to the planet. Vendors need to showcase their products, pictures are uploaded, content is downloaded. In summary, internet connection has practically become indispensable for a successful event.

1.2.1 Social Media

According to the 2018 Global Digital Reports elaborated by the We Are Social foundation, 3.196 billion people actively use some form of social media or social network online - and this number grows by an average of 13 percent every year. Attendees want, and often need, to share their experiences on an event. They often post pictures, opinions, complaints, and suggestions. Network engineers who design temporary networks for events must not only plan for a fast, reliable and stable connection for attendees, but also consider the security of this availability. At the same time that attendees want a free, easily accessible network, the project managers need to carefully isolate attendee networks from vendor networks. (EVENTOGY, 2018), which is an event management software company, on a recent blog post, considers social media interactions as the number one strategy for today's events:

> Digital marketing and social media campaigns have to form a seamless part of your event. Most importantly, they have to be

> something your guests can really engage with, either by sharing content or adding to it. Make your event marketing really stand out in 2018 by harnessing the power of social media, particularly Instagram and Snapchat. If it's appropriate, make sure your event has plenty of 'photo-worthy' moments that your guests will want to capture and share.

Another aspect of the network that more and more project managers are having to deal with is the live overall "mood" of the event's audience. Social analysers and AI-powered hashtag analysis are commonly found in modern network operation rooms on events. These tools compile public posts and hashtags, such as the one seen on figure 2, and help the event management to have a global understanding of the overall audience's thoughts. Figure 2 is an example of this, where an attendee tweets about the quality of the public WiFi service offered during an event. Network Managers need to constantly monitor user experience as a feedback for the quality of service.

Figure 2: An attendee tweets about the quality of the public WiFi service offered during an event.

Source: twiiter.com (2017)

1.2.2 Live Streaming

Many modern events, especially the ones which include keynotes and demonstrations, are streamed live to millions of viewers over the internet. During the 2016 Google I/O event, almost three million people watched the live stream of the main keynote (GOOGLE CHANNEL - YOUTUBE 2016). (EVENTOGY, 2018), an event Software Company comments about livestreaming on events on their blog:

> Livestreaming is already fairly popular at events, but there's still plenty of scope for introducing it to your conferences and meetings. It's a useful tool for allowing people to tune into major events remotely, and also makes sharing your content much easier. Many social media channels have introduced a live streaming functionality, such as Facebook Live, which means guests can broadcast events themselves, adding more opportunities for sharing.

The growth of the expectation over livestreaming means that network engineers need to plan, and design specific solutions to guarantee the success of the livestream. This usually requires network engineers to work closely together with audio/video engineers and camera operators. The good communication and information exchange between theses 2 teams are key factor for a successful live stream. On the network side, engineers usually allocate a completely separate infrastructure for live transmissions. This often includes a dedicated internet link, a backup link, which may be uplinked from the main link, and separate network devices such as dedicated switches and routers.

1.3 Motivation

In general, events have defined start and end dates, a planned site, and a well-defined target and public. Due to this temporary and versatile nature, events usually require solid, expandable and adaptable communication solutions. Event planners and engineers must be prepared to face the challenges imposed by such aspects in order to deliver a satisfactory connection project.

2 BASIC CONCEPTS APPROACHED

In this chapter the author will discuss some of the basic concepts that will be treated throughout the elaboration of this study. The main goal is to provide the basic background and knowledge of important concepts in order to provide a better understanding of the theme. It is important to note that, a computer network can have different purposes, objectives, sizes, and even technologies. The most common types of networks include Personal area network, or PAN, Local area network, or LAN, Metropolitan area network, or MAN, Wide area network, or WAN. In this study, the author will focus on local area networks and Wireless Local Area Networks, since these are the types of networks suited for local and relatively small installations, such as the ones found in buildings, homes, and other single-sited installations.

2.1 A Permanent Network Installation

The Cambridge English dictionary (CED, 2018) defines “permanent” as “something that lasts for a long time or forever”. In this sense, it is understood that a permanent network is a network that is designed to last for a long period of time, without the need for a rebuild in short-term, and without the prospective of short-term removal. A permanent LAN is also often referred to as a Campus Network. The importance of the appropriate planning and designing of such networks is enforced in Cisco’s campus network for high availability Design guide (CISCO Inc., 2008). The guide states: “Designing a campus network may not appear as interesting or exciting as designing an IP telephony network, an IP video network, or even designing a wireless network. However, emerging applications like these are built upon the campus foundation.” When planning and designing a campus network, the engineer needs to consider some very important aspects: Scalability, Security, Efficiency and costs. A permanent network is designed to last, and therefore must be prepared for future size expansions, technology evolution, and increase in requirements. A non-scalable network could require a complete rebuilt in case there is a need for expansion in throughput, number of users, physical size or technological standards – which would highly increase the costs of such installations in a long-term perspective.

Since they are made to last, it is important to note that permanent installations will eventually need maintenance. When designing such networks, a designer must have in mind that the network will suffer interventions from different people, in different times, and with different objectives. In these cases, it is very important to consider norms and standards in such installations. Network design norms exist in a variety of scopes. There are norms that regulate the technologies used, the physical position of the network equipment, the size and type of cables, the color of cables, the placement of the cables throughout the campus, the types of antennas used in wireless access points, the sizing of racks, the operating temperatures of server rooms, racks and equipment, the level of physical access permission to equipment, and even the type of documentation that will describe the deployment. All these norms exist in order to guarantee the correct functioning of the network for a long period of time and in order to allow maintenance to be performed whenever necessary.

2.2 A Temporary Network Installation

A temporary network installation is, by definition, a network that needs to perform for a determined amount of time. Temporary installations are usually deployed whenever there is a need for network connectivity in a place that is not meant to, and will not continue to offer connectivity after a determined period of time. This type of installation is sometimes required for the production of events, as discussed in chapter one. Temporary installations are usually LANs and WLANs, since most events take place in a single campus. Further details of how these networks differ from permanent networks will be discussed in chapter 3.

2.3 Switching

Switches are the basic foundation of most modern business and home networks. A switch is a device that is primarily responsible for transporting data on a physical layer and in performing error checking on each transmitted and received frame. A switch uses MAC Addresses to determine the path through which the data frames should be forwarded. (LEWIS, 2018) describes this process as such:

> A switch determines how to handle incoming data frames by using its MAC address table. A switch builds its MAC address table by recording MAC addresses on the nodes connected to each of its ports. After a MAC address for a specific node on a specific port is recorded in the address table the switch then knows to send traffic destined for that specific node out to the port mapped to that node for subsequent transmissions.

A collision domain is defined by (NAIK, 2016) as “the part of a network where packet collisions can occur. A collision occurs when two devices send a packet at the same time on the shared network segment. The packets collide and both devices must send the packets again, which reduces network efficiency”. Because switches determine the port to witch a frame must be sent, only the destination of each frame receives the frame. Therefore, a switch is also referred to as a device that isolates collision domains. Regarding this, (MEHTA, 2005) states that:

> “Switches break the network into multiple collision domains and hence simplify the expansion rules by avoiding the collision domain restrictions. They also allow the separate collision domains to communicate with each other.”

2.3.1 VLAN

A virtual LAN, or VLAN, operates at the switching layer and play an important role in the modern networks. They are especially important for temporary networks since they detain a series of advantages over traditional networking designs. To understand these advantages, one must first understand what a VLAN is. According to (MITCHEL, 2018c) a VLAN is

> “a logical subnetwork that can group together a collection of devices from different physical LANs. […] VLAN tags for Ethernet networks

> follow the IEEE 802.1Q industry standard. An 802.1Q tag consists of 32 bits (4 bytes) of data inserted into the Ethernet frame header. The first 16 bits of this field contain the hardcoded number 0x8100 that triggers Ethernet devices to recognize the frame as belonging to an 802.1Q VLAN. The last 12 bits of this field contain the VLAN number, a number between 1 and 4094".

The main benefits of using such range from security to practicality. In modern devices VLANs are very easy to setup and configure. They can me configured in a static form (in which a specific switch port is assigned to tag traffic with a certain VLAN tag) or in a dynamic form (in which the VLAN tag in the switch is programmatically set depending on the device that is connected). VLANs also bring additional security benefits to networks by allowing granular control over which devices have local access to each other.

2.4 SNMP

According to (SCHMIDT, 2005), the Simple Network Management Protocol, or SNMP, is an Internet-standard protocol for managing devices on IP networks. The author states that many kinds of devices support SNMP, including routers, switches, servers, workstations, printers, modem racks, and uninterruptible power supplies (UPSs). The main use of SNMP is to monitor the target devices, although the protocol is much more complex and capable than just monitoring. SNMP consists of a set of operations (and the information these operations gather) that gives the network administrators the ability to see and change the state of some device.

Using SNMP commands, a network administrator can verify many aspects of an equipment, such as temperature, CPU usage, memory usage, port usage, port speed, link state, operating system version and general errors/faults. But reading information is just part of what SNMP protocol can do. One very useful set of SNMP instructions allow modifying the configuration in the target device. For example, according to (SCHMIDT, 2005), SNMP can be used to shut down an interface on your router or change the 802.1Q VLAN tag on a switch port.

3 DIFFERENCES BETWEEN TEMPORARY AND PERMANENT INSTALL

Due to the nature of temporary network installations, and taking in consideration that installers need to be prepared and aware to face unique sights, it is important to note the main differences between temporary and permanent installations.

3.1 Norms

When considering temporary deployments, most of the bureaucracy that involves a network installation is disconsidered. In Brazil, network deployments are regulated by *ABNT NBR 16415:2015 - Caminhos e espaços para cabeamento estruturado,* which compiles a set of rules and best-practices for certifications. Figure 3, below, is an example of a patch-panel with colored, structured cabling.

Figure 3 - Example of a patch-panel with colored, structured cabling - items usually disregarded in temporary installations.

Source: (BANDEIRA, 2014)

In practice, most of these norms can be disregarded on temporary installations, since these deployments do not require long-term availability, and maintenance is usually done by the same people who deployed it. Although most of the norms that deal with bureaucracy and maintainability can be disconsidered, the norms that affect the direct operation of the network (in terms of speed and trustability) are usually followed.

Examples of norms that can (and are) usually disregarded in temporary installs include the positioning of active network elements (switches and routers) in racks, the labeling of cables and patch cords, color differentiation on cabling, color differentiation and separation with Velcro, the use of patch panels between horizontal cables and switches and the use of conduits, electrical conduits and cable beds for laying cables. Norms that are usually widespread even on temporary installs include the 90-meter cable length limit, preference for pre-made cables in relation to crimped cables, and avoiding to run network cables along with electrical cables. Also, as a form of compensating for the less restrictive use of the norms, most temporary installs will prefer to deploy Category 6 UTP cables, as to guarantee gigabit speeds.

Although the lack of norm enforcement can make temporary networks seem easier to implement, a network engineer must be prepared for all the challenges that a temporary install can present. The first difficulty that any project manager who is managing a temporary network deployment will face is the site itself. Events can take place on any sort of area, and the network project manager needs to be prepared to overcome the challenges of the place. Many events take place on open areas, where no physical network infrastructure is present. These often require a setup of a network core, a backbone, and every single cable run, for users and for access points. Also, the project manager needs to be aware of weather conditions, and weather threats in order to avoid damages to the equipment, and to ensure that the network functions properly. Other events take place in conference centers, hotels, and even on existing business centers - but require a complete takeover of the existing structure for security reasons.

3.2 Weather Conditions

When designing and projecting an outdoor or hybrid network deployment, the network engineer needs to account for all types of weather conditions that the deployment might have to face. Gear that need to be outdoors must be properly protected from rain and snow, thus requiring special cases, enclosures or even improvised protection. Most manufacturers offer outdoor versions of switches, and access points, but, in many cases these specially designed equipment is not available and the project manager needs to improvise solutions for protecting the gear. Another weather condition that must be considered on outdoor installations is lightnings. A lightning strike can cause severe damage to network equipment, and even propagate the damage to other actives in the network.

3.3 Cable Management

One of the most important areas that a temporary network engineer needs to plan is cable management. Unlike permanent installs, with structured cabling, temporary installs require an extreme level of improvising, and carefulness on where, and how, cables are run. In most cases, cables must be run on open areas, and at the same time, must be well hidden from attendees, and protected from accidental stepping, tripping, and event bending.

Figure 4 - Gaffers Tape.

Source: ViralInUSA (2018)

As depicted in Figure 4, Gaffer's tape is perhaps the most widely used form of cable management on temporary network installations. In many cases, this kind of tape is used to protect and hide cable runs, due to its high level of fixability and toughness. Gaffer's tape is made for the film and theater industry for taping down cables without causing damage to the surface, such as carpets and floors

3.4 The Wireless Solution

As shown by web analytics company (STATCOUNTER, 2016), Internet usage by mobile and tablet devices exceeded desktop worldwide for the first time in October 2016. This means that today, most of the internet connectivity involve a wireless device, and this, in fact, also applies to the event industry.

According to the (GRATE, 2017 b), "the trend toward mobile is gaining major traction. [...] attendees and organizers are ditching their laptops in favor of mobile devices. Event organizers in particular are capitalizing on all the great new event apps and mobile-worthy websites that make productivity easy on the run." And this move towards mobility implies in greater reliability on wireless networks.

A project manager needs to pay special attention to the wireless solution of the installation. In permanent installations, access points are usually placed on the ceiling of the areas, but in temporary deployments this is usually not possible, or worthful. Instead, project managers must be creative and adapt the placement of the APs, as to reduce cable runs, keep the cleanliness of the event, without compromising the coverage of the wireless network. Placing access points on tripods around the event area, underneath seats, and even hidden inside bushes are some examples. Figure 5 shows an example of a WiFi access point placed on top of a tripod stand, to guarantee coverage over an open area. This technique is often used with and without external antennas.

Figure 5 - An example of a WiFi access point placed on top of a tripod stand, to guarantee

coverage over an open area. This technique is often used with and without external antennas.

Source: Author, 2017

Another challenge for the wireless project is density. Many events, specially keynotes and expositions accommodate a large amount of people - and devices - in a small space. Project managers need to plan for this high density, and carefully calculate the number of access points and their transmission powers to avoid overload on APs. Modern Access points such as the Cisco Meraki MR53, depicted in Figure 6, are able to adapt to high density, and when used with the Meraki Cloud solution are able to provide a detailed mapping of the area, and even to track clients and their movement throughout the place.

Figure 6 - Modern Access points such as the Cisco Meraki MR53 are able to adapt to high density

Source: meraki.cisco.com (2018)

3.5 Different Requirements

Another peculiarity of temporary installations is the number of third parties involved in the project. In most cases, when installing for a permanent network, the related parties are restricted to the network project itself. There is usually 1 or 2 ISP (internet service provider), the project manager and the client. The target users and the requirements are usually well known, and the site is, predominantly, well documented. When dealing, for example, with the management of a permanent network install for a company, the project will have to account for: Number of users, types of devices, use of existing infrastructure, number of internet links, failover and backup. Meanwhile, temporary installations, especially for events, can have a significant amount of parties involved - each with different requirements, different backgrounds, and different procedures. The project manager needs to account for all these variables and plan the deployment accordingly. Example of this would be that, media centers that cover an event could require high-speed connections, while exposition areas would require lower speeds but better cable hiding and management.

(MITCHEL, 2018a) describes VLAN as “a logical subnetwork that can group together a collection of devices from different physical LANs [Local Area Networks]. [...] VLAN traffic on Ethernet networks follow the IEEE 802.1Q industry standard. An

802.1Q tag consists of 32 bits (4 bytes) of data inserted into the Ethernet frame header. The first 16 bits of this field contain the hardcoded number 0x8100 that triggers Ethernet devices to recognize the frame as belonging to a 802.1Q VLAN. The last 12 bits of this field contain the VLAN number, a number between 1 and 4094."

In the temporary networks, VLANs play a significant role in helping engineers to re-partition the network for improved traffic management and segmentation. In most cases, using OSI Layer 3 protocols for routing traffic between subnets would provide an unnecessary level of complexity to a network, especially due to the fact that in an event environment, different segments of the network usually occupy a same space, whereas other instances of that same segment are physically located elsewhere. One example of this can be seen in an event with an exposition area and conference rooms. In the exposition area, different vendors occupy the same space, but they might all require different traffic handling, while, in conference rooms, each room must reside in the same LAN as the corresponding expositors in the exposition area. Using VLANs to specifically tag and isolate the traffic of different vendors makes managing the network much more straightforward and secure.

The fact that a modern ethernet switch can easily and promptly be configured to change a port from one VLAN to another is also ideal for temporary networks, due to the fact that they often require changes and repositioning of people, vendors, and items. Figure 7 shows an example of how a port can easily be changed from one VLAN to another using a single command in Cisco catalyst switches. This provides an extreme level of rapid configurability and flexibility for engineers.

Figure 7: On a Cisco Switch, a port can easily be changed from one VLAN to another using a single command. This provides an extreme level of rapid configurability and flexibility.

```
Switch(config)#
Switch(config)#int fa0/4
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 20
Switch(config-if)#exit
Switch(config)#
```

Source: cisco.com

Due to the benefits of using VLAN segmentation, the author of this paper has observed that in every single event he has worked on, VLAN has been the one and only form of traffic segmentation.

4 802.11 STATE OF THE ART AND NEW INDUSTRY STANDARDS

Curran (2018) describes the IEEE 802.11 as:

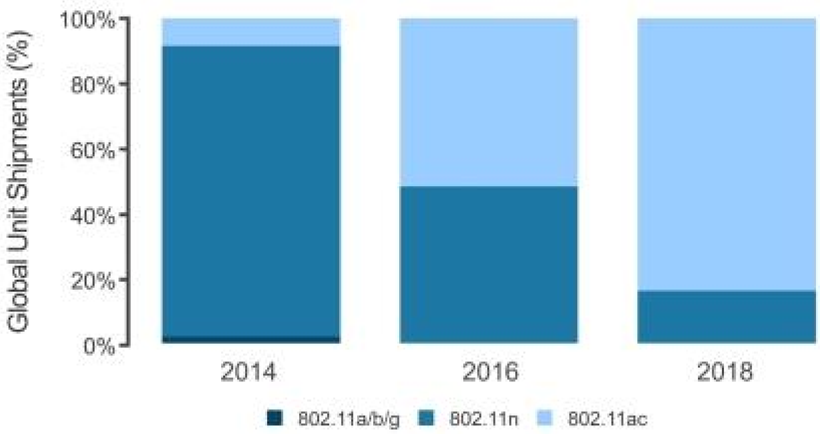
> a set of media access control (MAC) and physical layer specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands. They are the world's most widely used wireless computer networking standards, used in most home and office networks to allow devices to communicate with each other and to access the Internet without connecting wires.

Since its first specification, in 1997, 802.11 has seen many updates and upgrades to the standards, and has evolved drastically. In the late 1990’s, IEEE 802.11b became the first wireless LAN standard to be widely adopted and incorporated into computers and laptops. A few years later IEEE 802.11g was introduced. It offered signal transmission over short distances at speeds of up to 54 Mbps. Both standards, g and n, operated in the 2.4 GHz frequency range. In 2009, IEEE 802.11n (which operated in 2.4 GHz and 5 GHz frequency ranges) was introduced. The introduction of 802.11n was accompanied by the popularization of smartphones and mobile computing. According to (Estrada, 2011), 802.11n technology can provide up to 600 Mbps data rates, and such rates were, in big part, responsible for the popularization of the Wi-Fi technology. For the first time, everyday users were able to do over wifi, almost anything they did over cable.

In January 2014, IEEE approved the 802.11ac standard, which represents the 5th generation of Wi-Fi technology. According to (Mitchell, 2018a) e (Mitchell, 2018b), “To be competitive in the industry and support increasingly common applications like video streaming that require high-performance networking, 802.11ac was designed to perform similarly to Gigabit Ethernet.” In fact, 802.11ac can reach data rates of up to 1.3 Gbps. 802.11ac is able to reach such rates by using wider signal frequencies and a bigger number of MIMO radios and antennas. It also operates only on 5 GHz frequencies, unlike most previous generations of Wi-Fi that utilized 2.4 GHz channels.

In a document published by Market research firm Infonetics Research (BUSINESSWIRE, 2016) stated that in 2016 more than 50% of the WLAN devices were 802.11ac compatible, and forecasted that in 2018 this number would be over 90%. This document produced Figure 8, below, showing access point sales by 802.11 technology, and confirming the trend.

Figure 8 - Access point sales by 802.11 technology



Source: (BUSINESSWIRE, 2016)

As stated in Figure 8, 802.11ac operates in 5ghz frequency band only. According to (Klein, 2017), the 5 GHz band is much less congested, which means users will likely get more stable connections and higher speeds. But 5ghz has some disadvantages over 2.4ghz. The author states that “[...] the shorter waves used by the 5 GHz band makes it less able to penetrate walls and solid objects. ... [users] also got a shorter effective range than the 2.4 GHz band.”

To compensate for the shorter range of 5ghz, 802.11ac devices are backward compatible. This means that these devices also count on 802.11n radios, and fall back to this technology if needed.

Network engineers and project managers who design and implement wireless networks on a temporary installation must be aware of these conditions. To guarantee the high rates offered by 802.11ac, projects must include a larger number of access points, and a well calculated distribution of the APs throughout the site. But number of APs is not the only variable an engineer must consider when planning the wireless solution. The composition of walls on the site, the distribution of attendees over the site, the level of interference with other devices such as radios and AV equipment, and even the type of devices expected to attend, are all variables that must be taken in consideration when planning, and designing a temporary wireless network.

5 PROPOSED METHODOLOGY FOR TEMPORARY INSTALLATIONS

Based on the considerations covered in chapters 1 through 4, the author has developed a basic methodology to assist network designers and engineers in planning and setting up a temporary network deployment. The steps described in this chapter are not intended to be used as a scientific method, but as a guideline for such projects.

5.1 Understand the Event

The first step for a successful temporary deployment is to understand the event in a global manner. For such, the network designer should be able to answer the following questions: What is the main purpose of the event? Who is the client? What are the client's objectives with this event? Who is the target attendee? How many people are expected to attend the event? Answers to the questions above should allow for a general understanding of the event. The next step for the clear understanding of the event should be a detailed view of the technological requirements of the event. Does the event depend on a network connectivity, or is the network only going to be used for attendee connection to the internet? Will the event provide live streaming? Will there be essential services, such as apps, running on the event's infrastructure? What are the contractual link requirements required for each area of the event? Is wireless internet required?

5.2 Familiarize with the Site

Once having the understanding of the event as described in section 5.1, the designer should start to consider and understand the physical aspects of where the event will take place. This part includes understanding what the area where the event is built for. Is the event going to happen in a hotel? A conference center? A single room? A theatre? An open area, a stadium … These are some examples of sites that the author has had the opportunity to work at, but, as mentioned in chapter 3, an event can take place in practically any sort of place.

After having a clear image of what the place is, the next step is to understand how the place is presented. This is usually done by analyzing an architectural floor plan of the area, which is often provided by the customer together with the event floor plan. The architectural floor plan will allow the engineer to have a clear look of the area, the location of the rooms, the sizing of each ambient, and even details such as locations of power outlets. The event floor plan is where the client describes exactly what will be happening in each of the areas, points out all the areas that should have network coverage, and pictures the layouts and requirements of every different ambient in the event.

Specific peculiarities and restrictions of the site and the client must be considered too. In many cases, especially in technology-oriented events that take place in hotels, it is a requirement that the whole hotel network must be taken-control of, and none of the existing hotel network can be used.

5.3 Plan the Technology

Planning the technology is perhaps the most critical part of the network design, and the one that will require the most amount of technical knowledge. This step is heavily dependent on the previous two steps. Having a general idea of the area, the requirements, and keeping in mind the needs of attendees the network designer should start by planning the main link of the event. Bandwidth and redundancy are a critical decision, and should be planned with extreme caution. Sometimes clients provide the information of the bandwidth, but even in this case, the network designer must verify that the bandwidth is enough to cover for the needs.

After having the main link (and perhaps its backups) planned, the next step should be to consider the kind of technology to be implemented in the core of the network. A network designer must work closely with hardware manufactures or hardware providers in order to guarantee that the technology implemented will be able to handle the network requirements of the deployment. An incorrect product placement or a lack of compatibility between different equipment in a network can be disastrous for the success of an event – especially considering the fact that in an event situation, there is a small time-window for the setup process, and that replacing hardware could require a long time.

One of the most important parts in the technology planning is the placement of access points. In this step, it is indispensable that the designer has possession of the floor plans, since it will be the main source of information for the physical installation team. For such, many of the aspects covered in this paper must be considered.

a) What is the type of wireless technology that will be used?
   Answering this question will allow the designer to understand if the radio waves will be able to reach certain area, or overcome barriers such as walls and trees.
b) How many users are expected in each area?
   The answer to this question will allow the designer to correctly size the number of APs in the area, in order to avoid overloading of access points.
c) Are there any restrictions to the physical installation of the access points?
   Knowing how the APs will be attached, if there are any trusses or tripods, if they are required to be hidden, if they are required to be exposed.

At this point, the network designer should be able to estimate the amount of equipment that will be required for the setup. This includes the amount of cables, the amount of RJ45 connectors, the number of access points and access switches required, and even the tools that the team will have to carry – such as crimpers, fork-lifts, and team-communication radios.

5.4 Prepare for Deployment

One of the most challenging parts of the project is the correct sizing of the deployment team. A temporary network designer needs to be able to accurately predict the number of collaborators that will be required to install and deploy the whole event within the installation window. Events can happen in many different parts of the world, and a network deployment team must be prepared to face language and cultural barriers imposed by the location. For events in countries other that the country of origin of the network designer, it is recommended for the deployment team to be composed by a mixture of locals and foreigner collaborators. This will allow for a better integration between the network deployment team and the other teams assigned for the setup of the event.

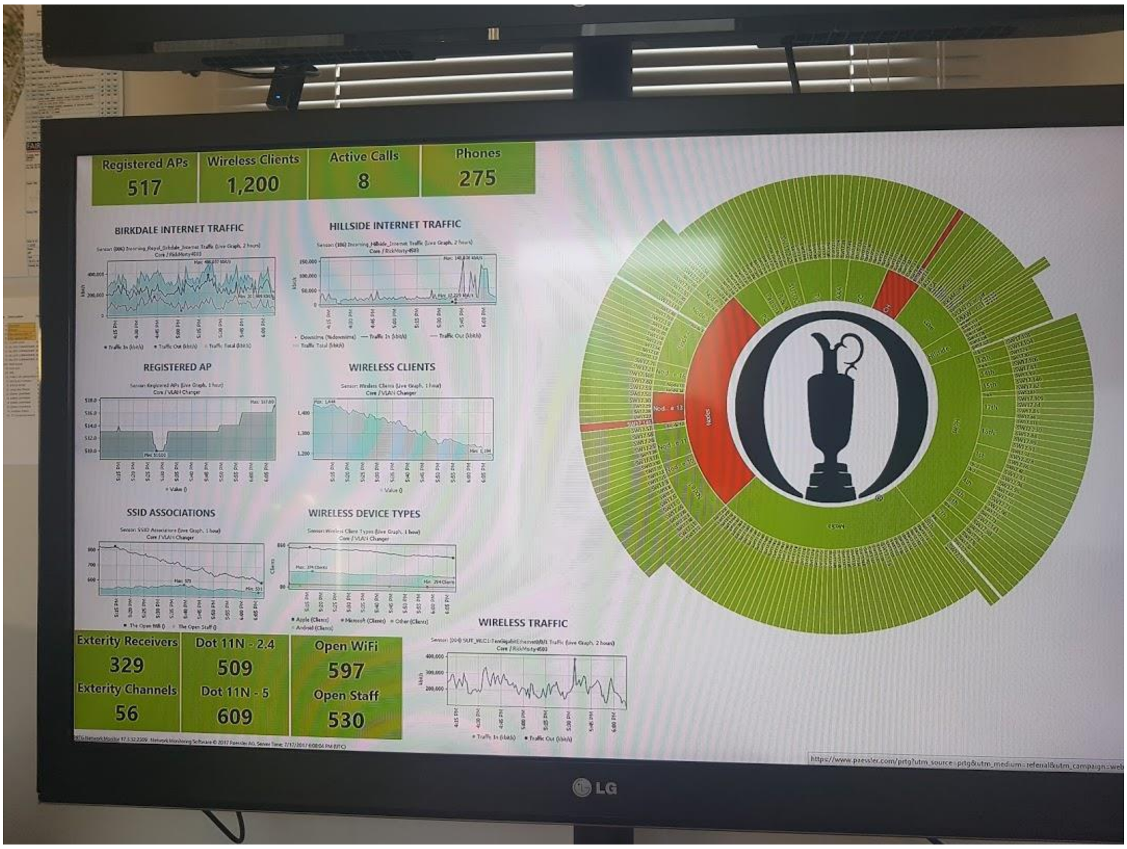
It is also recommended that network deployment teams be separated according to physical areas within the event instead of duties. This is recommended specially for large events, where multiple rooms, areas, and environments are required. The correct orientation and coaching of each team is crucial. A tool called Network Allocation Grid if often used, in conjunction with floor maps to orient the deployment teams. A Network Allocation Grid, or NAG, is a set of one or more tables, usually with visual color codes, that identify each one of the equipment used in the deployment (switches, routers, APs, printers, etc.), their respective locations, management IP address, VLAN, hostnames, and status. Cloud-based collaborative solutions such as Google Spreadsheets and Microsoft Office Excel 365 are perfect tools for NAGs since they allow for a real-time multi-user collaborative edition, where the deployment team and the network project manager can be in synchronization on the real-time state of the installation.

As stated in chapter 3, events usually have a tight and small window for setup. Deployment is usually only possible on days or event few hours before the beginning of the event. The network designer and project manager need to pay special attention to deadlines and time-frames. In some cases, it is recommended that part of the setup and configuration to be done in a separate area, such as an office or a warehouse, and then moved to the event site during setup days. The correct timing of the setup process depends on a close integration with the event producer. Some events use a certain area before they use other areas. Knowing this will allow the deployment team to focus on setting up the areas that will be used first.

5.5 Monitoring the deployment and its functionality

Once the setup is complete, and the event starts, the network designer should hand the network to the network monitoring team. In many cases, the network designer is also the leader of the monitoring team. The monitoring of the network and its uses usually require a smaller team that the setup, but its importance in critical. For so, several network monitoring tools and software are available in the market. It is recommended that a Network Operation Center is built. In this area, engineers can use network monitoring software to keep track of the reachability of each equipment in the network, the current use of the links, the real-time loads on access points, number of active clients, and monitor real-time security threats. Bigger events tend to attract a large attention from global groups, and cyber-attacks happen in a large amount of cases. Network monitoring teams must be prepared to quickly respond to, avoid and mitigate these threats.

Figure 9 – A Network Monitoring Software used for monitoring an event in real-time



Source: Author, 2017

5.6 Tearing Down

Despite given less attention, the disassembly process is also a very important part of the temporary network, and must be carefully planned. In many cases, there are strict contractual rules to be followed on the teardown. Conference centers, for example, usually have tight deadlines for this phase, since they must be prepared to host the next event. Some contracts impose fines to companies that leave any material or cable behind. So, a fast, and controlled teardown process must be executed.

Another very important aspect of the teardown is that network equipment is expensive, and must never be left behind or forgotten. To avoid forgetting equipment it is recommended that the disassembly be made from the farther-most points of the network to the core. Start by removing all the computers, printers, IP Phones, and any other host on the network. While this is done, the network monitoring team will still have access to all the access points and switches. The next step is to remove all the access points. With the monitoring software, the team will be able to see if any AP were forgotten. Once all the APs are disconnected and no more APs are seen in the monitoring software, teams can start removing the access switches. Always keeping in mind the outermost-to-core model. The last switches should be the ones that are directly connected to the core switch, and finally the core. Following this model will reduce the chances of forgetting equipment, but it is always important to execute a inventory check once everything is disassembled.

6 CASE STUDIES

The author of this paper has been working as a network engineer and project manager for the past 3 years, specifically in the event industry. He has had several experiences in deploying temporary networks in conference centers, stadiums, city halls, hotels, music concerts, and on wide open fields. This chapter focuses on the peculiarities and solutions faced on 2 specific events. The first one, held on a wide-open field, while the second one took place inside the biggest music festival in the world.

6.1 THE OPEN 2017

The first event studied took place in 2017. It consists of the second largest golf event in the world. The event was attended by more than 255 thousand people, on the spawn of one week. For this event, more than 340 48-port Cisco Layer 3 switches and over 100 12-port layer 3 switches were deployed. Over 600 Cisco 3500 AC Access Points were used, to implement a campus-wide, high speed wifi coverage.

Network engineers had to design a network capable of handling hundreds of VoIP phones, a broadcast center with more than 10 different TV and Radio Broadcasting companies, 2 separate public Wifi - one for the over 10,000 staff members, and one for the General Public, a media center capable of holding over 200 reporters and press conferences, more than 30 interconnected food and drink bars, VIP lounges, player lounges, and scoreboards spread throughout the course.

Despite the fact that this was a relatively big network, the whole solution was designed using primarily OSI Layer 2 and VLAN segmentation. A Core switch was responsible for inter-VLAN routing, and from this core, several fiber channels were deployed thought the course. Following a star model, every node had a stack of 4 48-port switches, which then, connected to smaller switches accordingly. Most of the backbone connection was made using monomodal glass fiber channels. This architecture provided to the technicians that worked on installing the network a flexible and easy configuration.

The Raspberry Pi’s are pocket-sized computers that run Linux operating system. To facilitate even more the configuration of each port accordingly, engineers came up with a cheap and very versatile solution: Using Raspberry Pi’s and simple python scripts, installers could easily change the VLAN tag of a switch port, without having to manually interfere with the switch configuration, and without having to call the network engineers for VLAN changes. All the installer had to do was to plug the device into the switch port he wanted to change the VLAN, click the button corresponding to the VLAN he needed, and the python scripts would handle the VLAN change using SNMP (Simple Network management Protocol) commands. This solution is depicted in Figure 9, below.

Figure 10 - Pocket computers with a screen and buttons. - A simple solution to rapidly changeports as needed.

Source: Author, 2017

To enable the functions of this solution, a Raspberry Pi management VLAN was created. This VLAN was configured to not allow access to the internet, by default. Inter-VLAN routing was implemented, to allow this VLAN to communicate with devices in other management VLANs. A centralized server was put in this same VLAN. This server served DHCP and acted as a control-server for the python scripts. Before the deployment of the switches, all of the access ports on every switch were configured by default in this Raspberry Pi VLAN. When a Raspberry Pi was connected to any access port, it would immediately acquire an IP address assigned by the DHCP server.

After being assigned an IP, the python script in the Raspberry Pi would discover information about the port it was connected to. This was done by using TCPDUMP and analyzing CDP packets sent by the switch on that specific port. CDP (Cisco Discovery Protocol) is a “proprietary Data Link Layer protocol developed by Cisco Systems. It is used to share information about other directly connected Cisco equipment, such as the operating system version and IP address”, port number and VLAN id. (OMNISECU.COM) After gathering information about the switch and the port number, the python script would inquire the user to inform what VLAN they would like to configure that certain port.

The python script, then, would send the information of switch IP, port number and desired VLAN to the server. The server would, then, send SNMP commands to that switch to assign that specific port to the desired VLAN. After some seconds, the server would send an SNMP command to bounce the port. The Raspberry Pi would, then, check CDP packets again to make sure the port was set to the desired VLAN.

For the wireless networks, a single high-density Cisco Wireless LAN controller was used. With a single WLC, engineers could easily analyze real-time Wifi usage, identify potential overloads, identify faulty APs, quickly respond to incidents and extract conclusive network insights. As stated before, over 600 access points were installed thought the course, which accounted for peaks of 11,239 concurrent wifi clients simultaneously. Many of these APs were outdoors.

To protect the equipment from the extreme and rapidly changing weather conditions of the site, engineers came up with solutions for packing external APs into sealed weatherproof containers. Using these containers instead of the manufactured outdoor APs, heavily reduced the cost of the deployment and also accounted for rapid AP replacement if necessary.

Figure 11 - Indoor 12-port switch and Access Point sealed and prepared for external usage. These boxes were mostly placed under bleachers and hidden in trees.

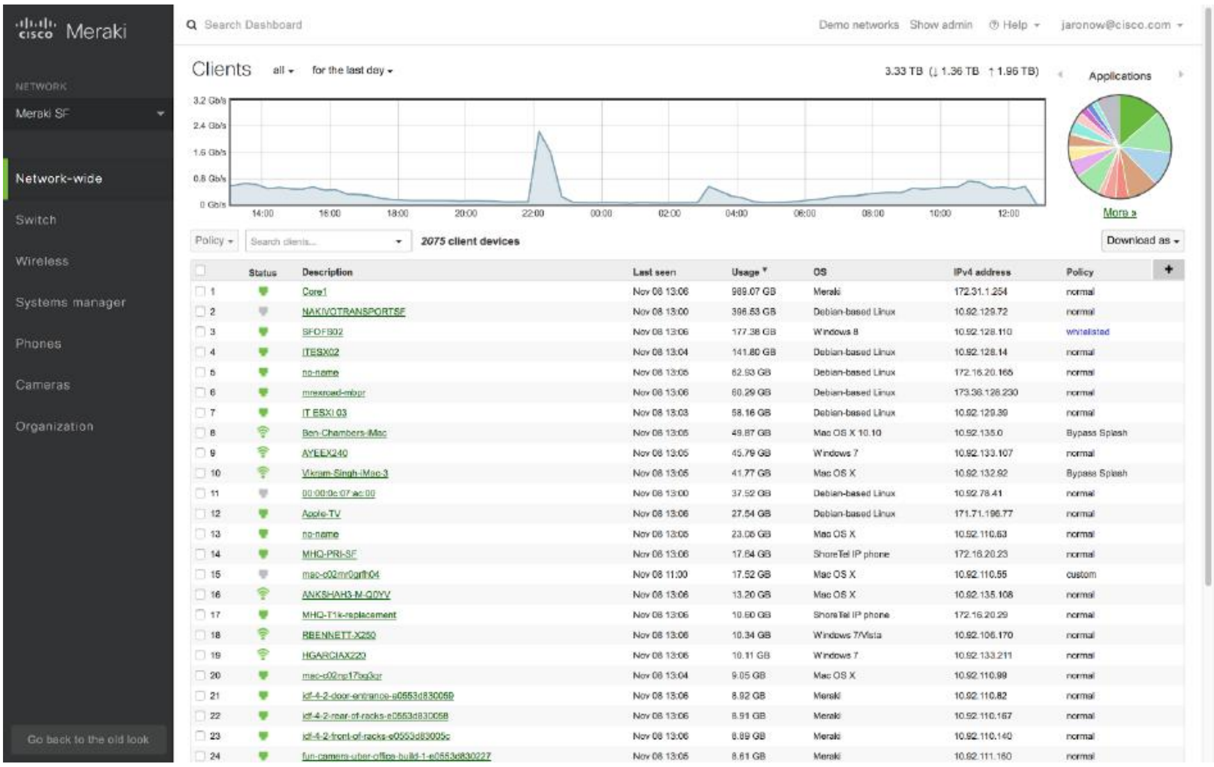
Source: Author, 2017

Despite all the precautions taken with grounding, and protecting external gear, 2 incidents with lightning strikes were registered during the event. The first one only affected the access point, while the second lightning strike resulted in the burning of one access point, and two switches that were connected to by CAT6 UTP cables.

5.2 NBA FAN ZONE - ROCK IN RIO 2017

This particular deployment took place in South America. This specific setup was part of a larger setup - the biggest music festival in the world. The Fan Zone was held inside an indoor stadium, and consisted of a showcase where fans and visitors could interact with several basketball players and basketball games - virtually and in person. Due to the nature of the event, and the limited resources overseas, and the reduced staff, project managers decided to deploy a full Cisco Meraki solution for the event. Cisco Meraki offers plug-and-play cloud-managed network devices - such as switches, routers, firewalls, Access Points, IP Phones and IP Cameras. All the network actives are configured, controlled and monitored through a single cloud-based GUI (Graphical User Interface) dashboard. An example of this GUI can be seen in Figure 11, bellow. From the dashboard, engineers can have access to granular information such as user count, network usage, link states, port link statuses, VLAN utilization and even detailed mapping on wireless client’s positions and movement throughout the whole event area.

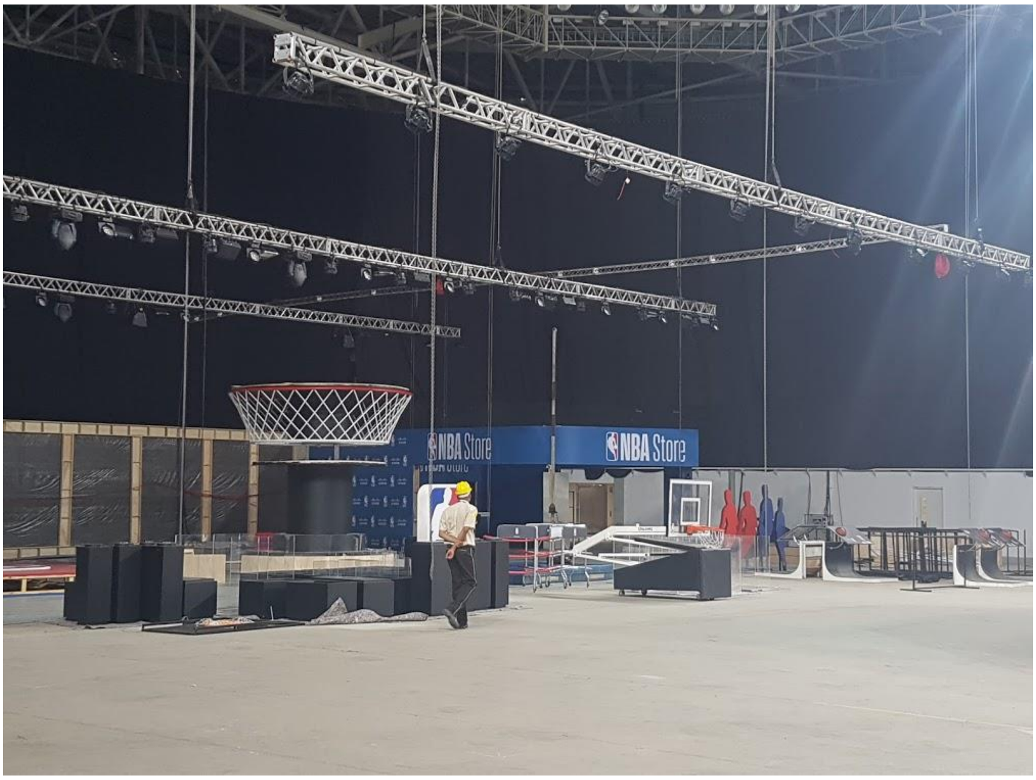
Figure 12 - An overview of the Meraki Dashboard - a single GUI dashboard to manage a whole network.



Source: meraki.cisco.com

For the wireless infrastructure, engineers used 30 Meraki MR53 access points. Due to the fact that the event was setup inside an indoor stadium, the APs were placed on elevated trusses, which were lifted 8 meters high. This way, APs could be distributed evenly, which guaranteed 100% WiFi 802.11AC coverage of the whole area. Figure 12, bellow, exemplifies the use of trusses, which allow a cleaner placement and better distribution of Wireless Access Points.

Figure 13 - When possible, trusses allow a cleaner placement and better distribution of Wireless Access Points.



Source: Author, 2017

7 CONCLUSION

The temporary nature of network installations for events and exhibitions is a huge challenge for network designers and engineers. Being able to plan accordingly and in advance, taking into consideration all the challenges exposed in this document – and others that may appear – and quickly respond to unforeseen abnormalities are the key for a successful deployment. The success of a temporary deployment does not depend only on the aspects covered by this work, but to consider what has been exposed here should be a sufficient guideline for someone who need to accomplish a temporary network.

As stated in chapter 5, the objective of this paper is not be a scientific guide, but a compiled of experiences acquired by the author. The author believes that a definitive method for events and exhibition network deployments will never be completely accurate, due to the diverse nature of events and the fast rate in which technology and its requirements evolve. Experience will always be the best counselor and the more events an engineer builds, the more he or she will be able to contribute to this work and to the deployments of temporary networks worldwide.

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